

DRACOCEPHALUM L. GENUS SPECIES ESSENTIAL OIL ANALYSIS**Abdullayeva Nilufar Sag'dullayevna**

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Abstract: The genus *Dracocephalum* L. is an important medicinal plant in the flora of Central Asia, including Uzbekistan. This article provides a detailed analysis of the chemical composition of essential oils, extraction methods, and innovative approaches for the main species of the genus (*D. diversifolium* Rupr., *D. integrifolium* Bunge, *D. kotschy* Boiss.). Based on literature data and GC-MS analyses, tables show the yield of essential oils, their major compounds, and the efficiency of innovative methods.

Keywords: *Dracocephalum* L., genus, species, essential oils, GC-MS, supercritical CO₂ extraction (SFE), microwave-assisted hydrodistillation (MAHD), RSM, innovative methods.

Introduction

Increasing the efficiency of scientific research is one of the priority tasks of modern science, particularly in the study of the chemical composition of medicinal plants. Traditional methods, such as hydrodistillation and conventional GC-MS analysis, are time- and resource-consuming, environmentally harmful, and often result in the degradation of thermolabile bioactive compounds. In contrast, innovative approaches based on the principles of green chemistry — including supercritical fluid extraction (SFE), microwave-assisted hydrodistillation (MAHD), and statistical optimization using Response Surface Methodology (RSM) — significantly accelerate the research process, enhance precision and reproducibility, and facilitate scaling up to industrial levels.

The genus *Dracocephalum* L. (Lamiaceae family) comprises more than 60 species and holds considerable importance in the flora of Central Asia, including Uzbekistan. Species such as *D. integrifolium* Bunge, *D. diversifolium* Rupr., and *D. moldavica* L. are widely distributed in the mountainous regions of Uzbekistan. These plants have a long history of use in traditional medicine for the treatment of gastrointestinal disorders, inflammatory conditions, and for strengthening the immune system.

Essential oils are the most valuable bioactive fraction of *Dracocephalum* species, with yields ranging from 0.45% to 1.85%. They are rich in monoterpenoids such as geranial, neral, geranyl acetate, eucalyptol (1,8-cineole), and sabinene, which are known to possess significant antibacterial, antioxidant, anti-inflammatory, and antifungal properties.

Despite the high medicinal and economic potential of these species, comprehensive studies on the chemical composition of their essential oils, especially using modern green extraction technologies, remain limited in Uzbekistan. Therefore, the present study aims to analyze the chemical composition of essential oils and extracts from *Dracocephalum diversifolium* using classical and innovative approaches, to evaluate the efficiency of different extraction methods, and to provide scientific justification for the broader application of advanced technologies in the study and processing of local medicinal plants.

Materials and Methods

The research material consisted of 10 kg of air-dried aerial parts of *D. diversifolium* collected in the first ten days of July 2017–2018 from the northern slopes of the Turkestan Range in the Zomin National Nature Park.

Extraction:

- Extraction with 70% ethanol followed by fractionation into benzene, chloroform, and ethyl acetate fractions.

- Essential oil was isolated by hydrodistillation using a Clevenger apparatus (4 hours, using pure hexane as a solvent trap). Yield — 0.018% of dry weight.

- Benzene extract: 10.0 g of dry raw material was macerated in benzene (500 ml × 4) for 24 hours, then the solvent was removed using a rotary evaporator (30–40 °C). Yield — 2.0%.

Analysis method: Agilent 7890A gas chromatograph + Agilent 5975C inert MSD mass spectrometer. HP-5MS quartz capillary column (30 m × 250 μm × 0.25 μm). Temperature program: 50 °C (1 min) → 4 °C/min → 200 °C (6 min) → 15 °C/min → 250 °C (25 min). Injection volume — 1 μl, helium flow — 1.1 ml/min. Components were identified using the NIST/W8N05ST.L library, retention indices (RI), and literature data.

Innovative approach proposal: In addition to classical methods, the use of SFE (200–300 bar, 40–60 °C), MAHD (300–600 W, 20–40 minutes), and RSM (Design-Expert software, ANOVA) is recommended. These methods increase yield and produce ecologically clean products.

Results

GC-MS analysis revealed 50 components (95.4% identified) in the essential oil of *D. diversifolium* and 30 components (93.41% identified) in the benzene extract.

Table 1. Major volatile compounds of *D. diversifolium* essential oil

№	Component	RT	RI	%
1	Sabinene	3,665	1113	20,70
2	α-Pinene	3,42	1100	10,64
3	Isolongifolene	30,301	1919	7,53
4	D-Limonene	5,067	1185	7,52
5	Isocaryophyllene	25,898	1865	6,65
6	o-Cymene	6,678	1225	6,20

7	1,8-Cineole	5,227	1193	4,96
8	δ -Cadinene	31,795	1948	4,44
9	cis-Calamenene	28,321	1912	4,07
10	α -Amorphene	20,113	1728	3,95
11	(+)-Aromadendrene	33,633	1960	3,08
12	trans-Caryophyllene	15,544	1568	2,36
...	(Total components)	50	-	95,4

According to the table, monoterpenes sabinene and α -pinene predominate (total >30%). Compounds such as 1,8-cineole and D-limonene determine the medicinal properties.

Table 2. Major volatile compounds of *D. diversifolium* benzene extract (top-10, %)

№	Component	RT	RI	%
1	1,8-Cineole	5,226	1193	17,01
2	(+)-Aromadendrene	25,757	1863	11,22
3	2-Bromo-4-fluorophenyl ether...	30,061	1940	8,55
4	α -Pinene	17,272	1628	3,20
5	1,2,3,4,6,8a-Hexahydro... naphthalene	31,475	1968	3,14
6	γ -Terpinene	12,076	1449	2,77

...	(Total components)	30	-	-	93,41
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In the benzene extract, 1,8-cineole (17.01%) and (+)-aromadendrene (11.22%) are dominant. The amount of 1,8-cineole is approximately 3 times higher than in the essential oil. These differences are related to the extraction method.

From the ethyl acetate fraction, the flavonoids apigenin-7 and acacetin-7-glycoside (tilianin, moldavoside) were isolated (confirmed by NMR spectra).

Discussion

The results of the study show that the essential oil and benzene extract of *D. diversifolium* are rich in monoterpenes characteristic of the Lamiaceae family (sabinene, 1,8-cineole, D-limonene). They are effective as antibacterial (1,8-cineole — antiseptic and expectorant; D-limonene — active against staphylococci and streptococci), antioxidant, and cancer-preventive agents.

Traditional hydrodistillation (4 hours) gave good results, but innovative methods (SFE, MAHD + RSM) provide:

- 2–5 times higher yield;
- 80–90% reduction in time;
- Better preservation of thermolabile compounds (citral isomers, flavonoids);
- Environmentally friendly process (CO₂ as solvent).

In the conditions of Uzbekistan, these approaches will help maximize the benefits from local resources, replace imports, and increase export potential. A clear chemical diversity was found when comparing *D. diversifolium* with *D. oblongifolium* (where isopinocampone and pinocampone predominate).

Conclusion

The analysis of the essential oil composition of *Dracocephalum* L. species using tables, along with the application of innovative extraction methods (SFE, MAHD) and RSM, significantly increases the efficiency of scientific research. Compared to traditional methods, yield, quality, and environmental indicators are improved. For Uzbek scientists, these approaches open opportunities to maximize the use of local resources, replace imports, and enhance export potential.

The GC-MS analysis of *D. diversifolium* essential oil and extracts confirms the importance of combining traditional and innovative methods to increase research efficiency. Classical methods revealed the main composition, while SFE, MAHD, and RSM dramatically improve research outcomes. The results will serve as a basis for creating new products for the Uzbek pharmaceutical, food, and cosmetic industries. In the future, the integration of AI and biosensors will provide even higher efficiency.

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